Lane Detection from Video Clips Using Binarization and Sliding Window

Qingyuan Fan & Tong Yuan

School of Microelectronics, SUSTech

fanqy2018@mail.sustech.edu.cn & yuant2018@mail.sustech.edu.cn

Introduction

As self-driving car become an emerging booming technology, several main technical issues began to be widely researched including obstacle detection, routine planning, road lane detection and danger estimation. Within all the issues, lane detection provides reference information to the control of a car. In this article, we propose a method to detect and mark lane lines using a Binarization and Sliding Window technology.

Problem and Dataset

- The dataset of TuSimple Competitions for CVPR2017 contains 7000 1-second-long daytime highway video clips of 20 frames each, with the lanes on the final frame labeled.
- The output should be:
  - The lane separation lines of current lane (both marked on the frame and stored in json format).
  - The edges of the lanes on left and right (if any)
  - The deviation from the lane.

Fig. 1: Sample Image of TuSimple Competitions for CVPR2017 Dataset

Overall result

- Overall accuracy $\geq$ 85% under TuSimple Competitions for CVPR2017 dataset.
- In straight roads and curves with clear markings, accuracy $\geq$ 95%.
- The system can recognize the lane at 40fps with the frame resolution of 1280X720.

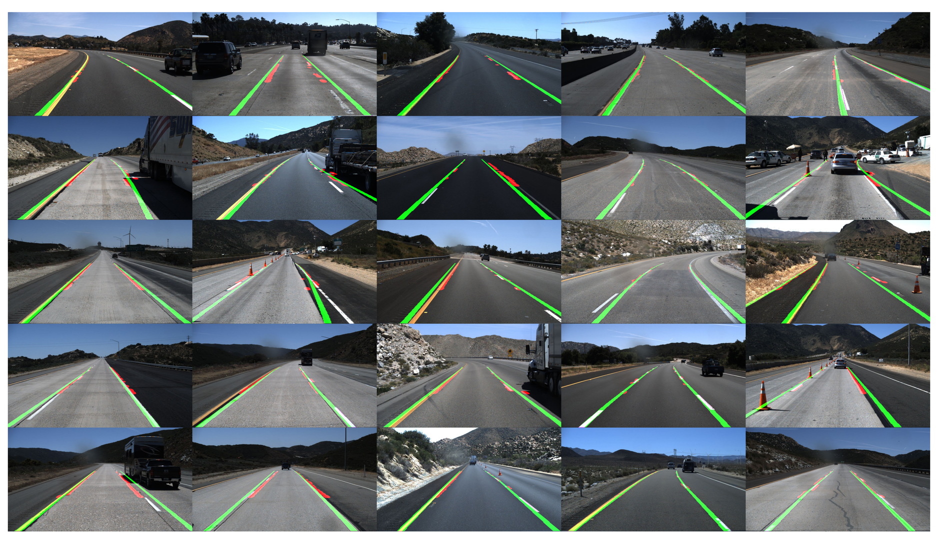

Fig. 2: Some frames in the recognition result

Why Sliding Window?

Despite the requirement of the course project, our algorithm that involved Binarization and Sliding Window has the following advantage comparing to the CNN-based algorithms that was popular recently.

- Can run without relying on specify hardware (such as GPU, TPU).
- Traditional computer vision methods do not require pre-training on the data set.
- Referring to the previous frame to prevent sudden debris.

General Workflow

1. Preprocessing
   (a) Find the reference camera view and undistorted the input image.
   (b) Transform the lane part of the image into a plane.
2. Binarization
   (a) Extract the image on RGB, HLS and lab colour plane.
   (b) Select the color of the lane line: select yellow in the LAB color space, and white in the LAB and RGB color space.
3. Edge detection
   (a) Applied Hough line transformation and remove horizontal lines ($\leq 10°$) and outliers.
   (b) Apply sobel filter for edge detection.

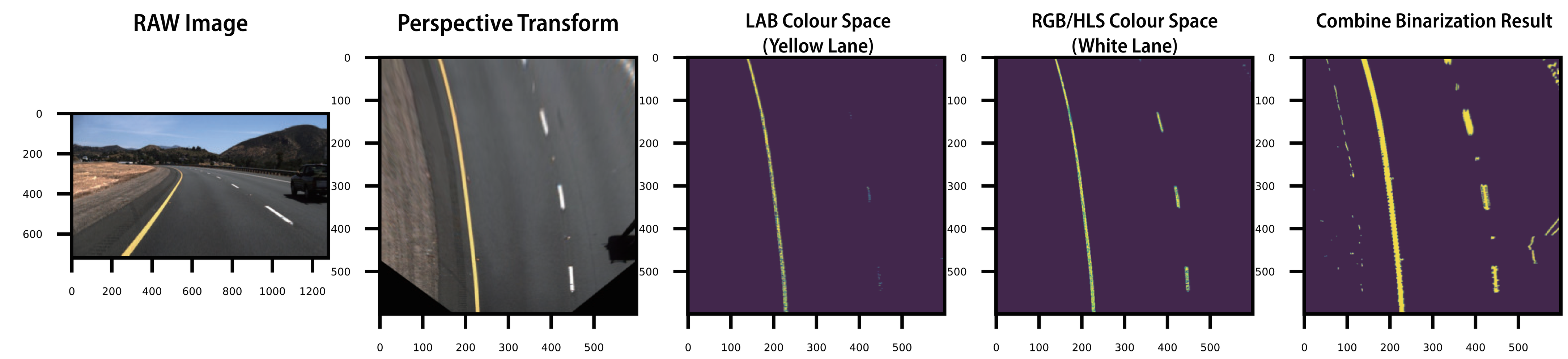

Fig. 3: Prespective Transformation and Binarization

4. Sliding Window Extraction
   (a) Find the start point of the line.
   (b) Using sliding window to follow the lane, write the axis of the point into list array.

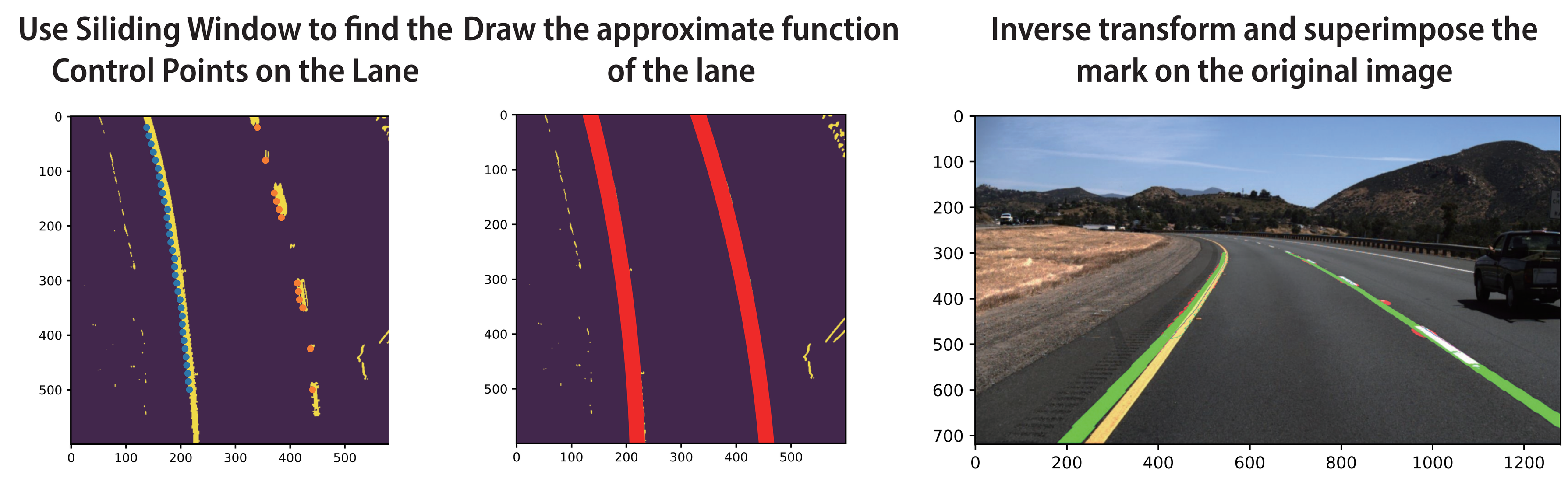

Fig. 4: Workflow of Sliding Window Extraction and Lane Mark Appending Process

5. (Optional) Use Previous Frames to Improve Accuracy
   (a) Read the previous 10 frame into buffer and poll it at the preprocessing stage.
   (b) Align the frame and use the maximum value of the frames.
   (c) The rest of the workflow is as same as above.

Result Evaluation

- Highlights
  - The algorithm has high accuracy for identifying well-lit road lanes.
  - Compared with the algorithm that only uses Hough transform and edge detection, our algorithm has a higher robustness in scenes with unclear curves and road lane lines or scene with high contrast.
- Issues
  - Such algorithm may consider the edge of the shadow as the edge of the lane line, which may cause recognition errors.
  - If there is a big vehicle obstructing the road, the sliding window algorithm could recognize the edge of the car as the edge of the lane.

Future Work

Compared to binarization in color space, the multi-layer convolution layer may have a better performance on the case of high complexity. Such algorithm might be apply on the the system to improve its accuracy and robustness.

Supplementary Information

- The code of the framework can be retrieved from https://github.com/sparkcyf/SUSTech-EE326-Digital-Image-Processing-Project under MIT license.

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Fig. 5: An autonomous driving test car under the building of the college.